

# HEF4020B

## 14-stage binary counter

Rev. 04 — 4 December 2008

Product data sheet

## 1. General description

The HEF4020B is a 14-stage binary counter with a clock input ( $\overline{CP}$ ), an overriding asynchronous master reset input (MR) and twelve fully buffered outputs (Q0, and Q3 to Q13). The counter advances on the HIGH to LOW transition of  $\overline{CP}$ . A HIGH on MR clears all counter stages and forces all outputs LOW, independent of the state of  $\overline{CP}$ . Each counter stage is a static toggle flip-flop. A feature of the device is its high speed (typ. 35 MHz at  $V_{DD} = 15$  V).

It operates over a recommended  $V_{DD}$  power supply range of 3 V to 15 V referenced to  $V_{SS}$  (usually ground). Unused inputs must be connected to  $V_{DD}$ ,  $V_{SS}$ , or another input. It is also suitable for use over the full industrial ( $-40$  °C to  $+85$  °C) temperature range.

## 2. Features

- High speed operation
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- Operates across the full industrial temperature range  $-40$  °C to  $+85$  °C
- Complies with JEDEC standard JESD 13-B
- ESD protection:
  - ◆ HBM JESD22-A114E exceeds 2000 V
  - ◆ MM JESD22-A115-A exceeds 200 V

## 3. Applications

- Industrial

## 4. Ordering information

**Table 1. Ordering information**

All types operate from  $-40$  °C to  $+85$  °C.

Type number	Package		Version
	Name	Description	
HEF4020BP	DIP16	plastic dual in-line package; 16-leads (300 mil)	SOT38-4
HEF4020BT	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1

5. Functional diagram

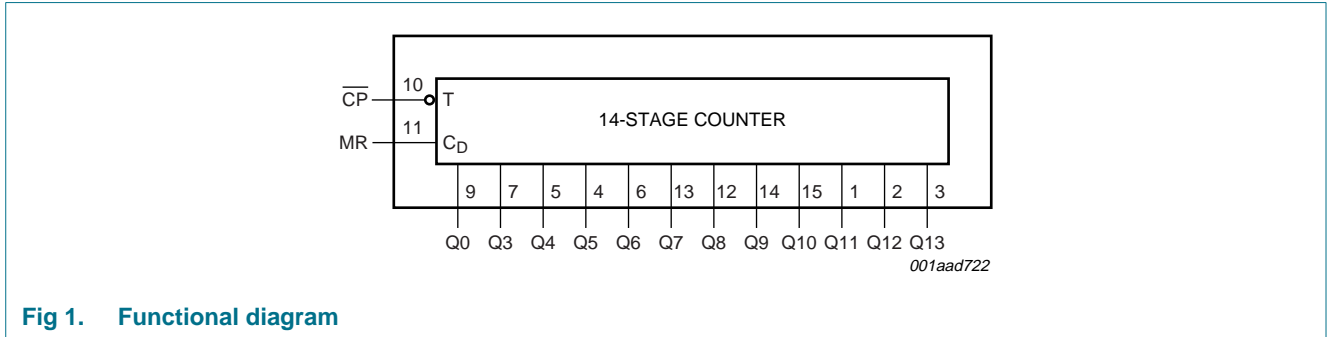


Fig 1. Functional diagram

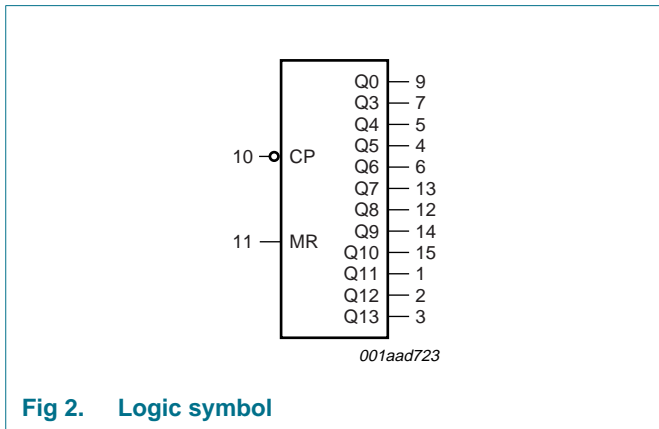


Fig 2. Logic symbol

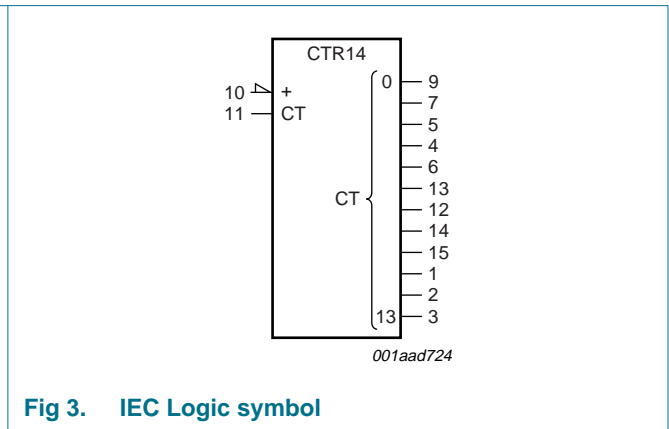


Fig 3. IEC Logic symbol

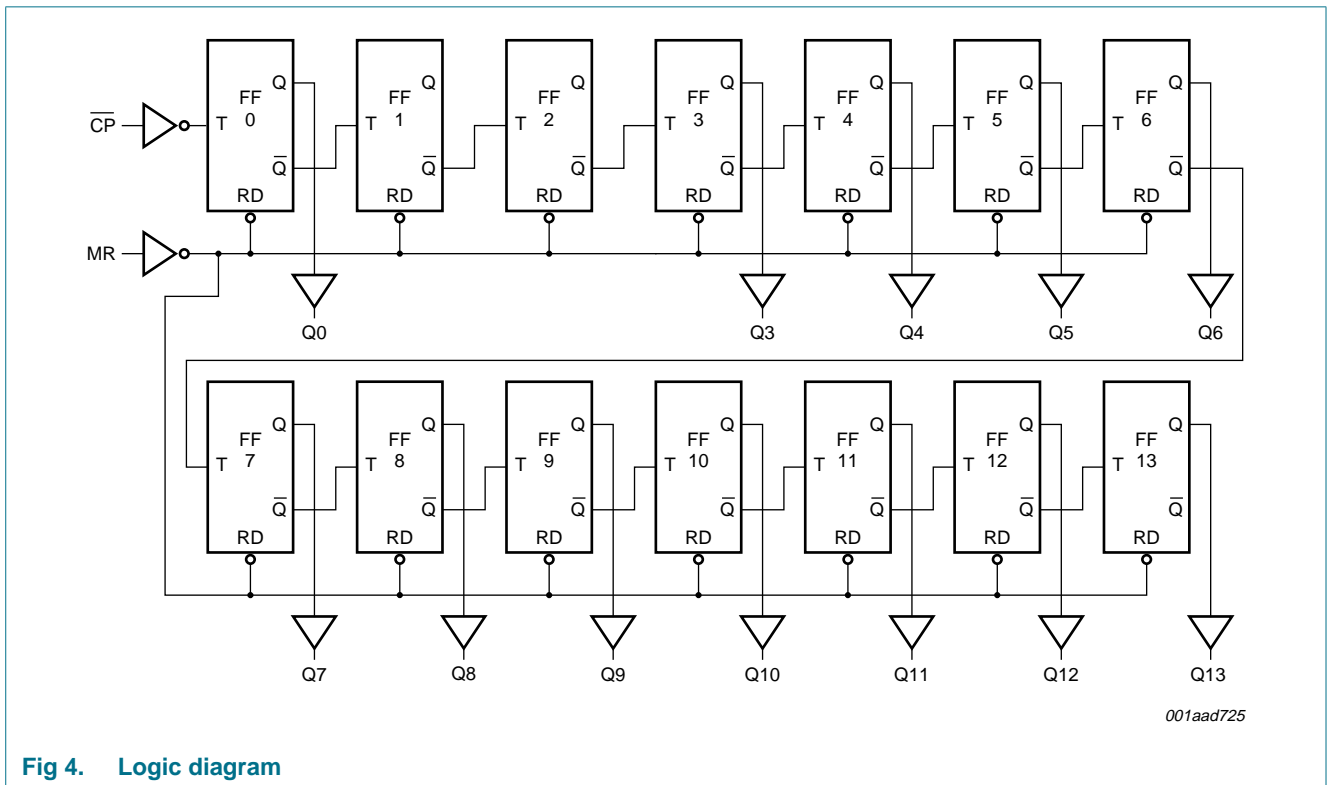
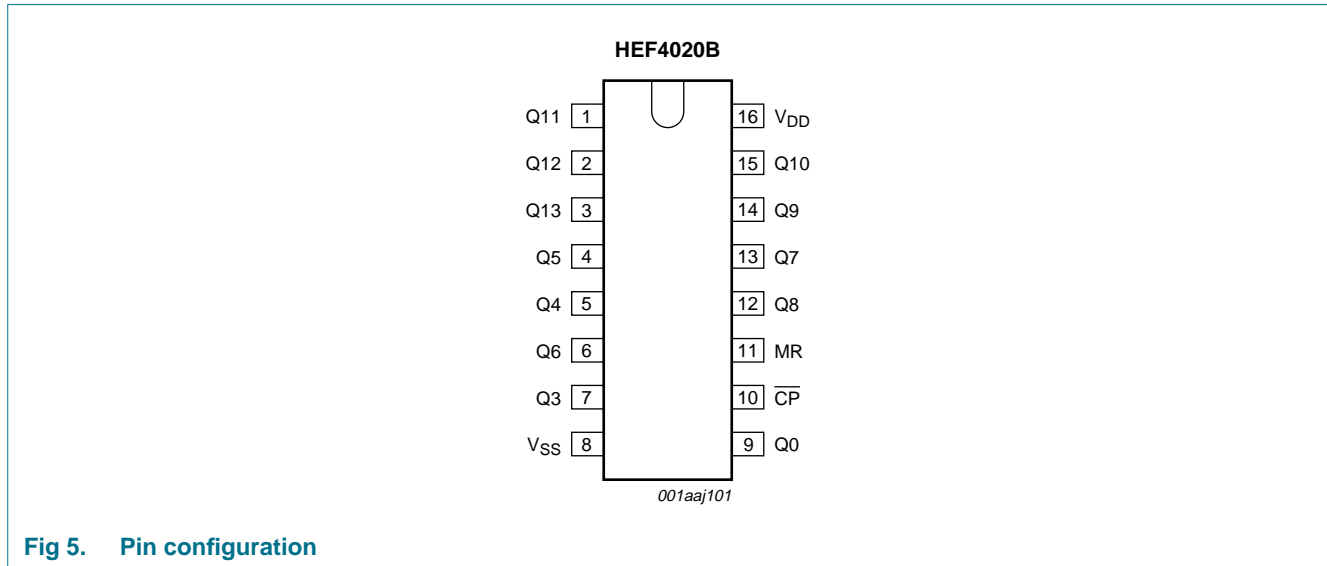


Fig 4. Logic diagram

## 6. Pinning information

### 6.1 Pinning



### 6.2 Pin description

**Table 2. Pin description**

Symbol	Pin	Description
Q3 to Q13	7, 5, 4, 6, 13, 12, 14, 15, 1, 2, 3	parallel output (Q3 to Q13)
V <sub>SS</sub>	8	ground supply voltage
Q0	9	parallel output
CP	10	clock input (HIGH-to-LOW edge triggered)
MR	11	master reset input (active HIGH)
V <sub>DD</sub>	16	supply voltage

## 7. Functional description

**Table 3. Functional table<sup>[1]</sup>**

Input		Output
CP	MR	Q0, Q3 to Q13
↑	L	no change
↓	L	count
X	H	L

[1] H = HIGH voltage level; L = LOW voltage level; X = don't care; ↑ = positive-going transition; ↓ = negative-going transition.

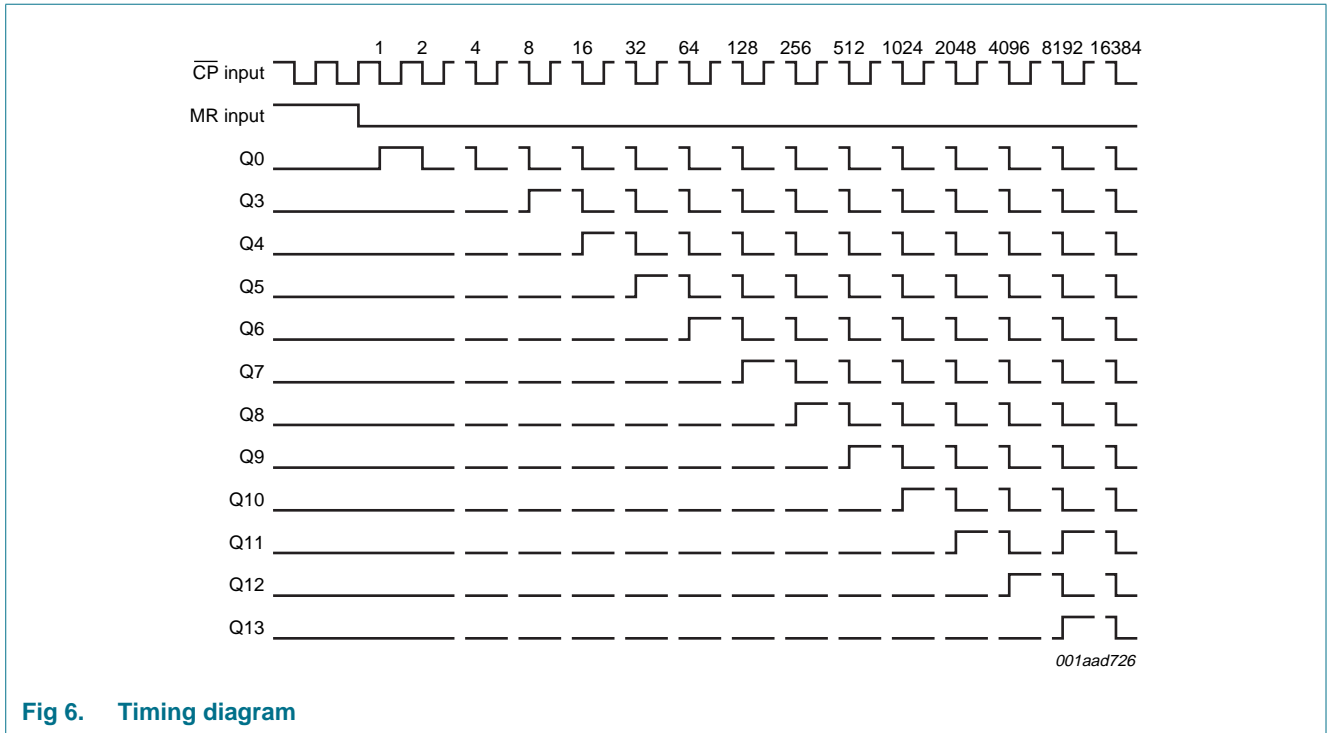


Fig 6. Timing diagram

## 8. Limiting values

Table 4. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit	
$V_{DD}$	supply voltage		-0.5	+18	V	
$I_{IK}$	input clamping current	$V_I < 0.5 \text{ V}$ or $V_I > V_{DD} + 0.5 \text{ V}$	-	$\pm 10$	mA	
$V_I$	input voltage		-0.5	$V_{DD} + 0.5$	V	
$I_{OK}$	output clamping current	$V_O < 0.5 \text{ V}$ or $V_O > V_{DD} + 0.5 \text{ V}$	-	$\pm 10$	mA	
$I_{I/O}$	input/output current		-	$\pm 10$	mA	
$I_{DD}$	supply current		-	50	mA	
$T_{stg}$	storage temperature		-65	+150	°C	
$T_{amb}$	ambient temperature		-40	+85	°C	
$P_{tot}$	total power dissipation	$T_{amb} -40 \text{ °C to } +85 \text{ °C}$				
		DIP16 package	[1]	-	750	mW
		SO16 package	[2]	-	500	mW
P	power dissipation	per output	-	100	mW	

[1] For DIP16 package:  $P_{tot}$  derates linearly with 12 mW/K above 70 °C.

[2] For SO16 package:  $P_{tot}$  derates linearly with 8 mW/K above 70 °C.

## 9. Recommended operating conditions

**Table 5. Recommended operating conditions**

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{DD}$	supply voltage		3	-	15	V
$V_I$	input voltage		0	-	$V_{DD}$	V
$T_{amb}$	ambient temperature	in free air	-40	-	+85	°C
$\Delta t/\Delta V$	input transition rise and fall rate	$V_{DD} = 5\text{ V}$	-	-	3.75	ns/V
		$V_{DD} = 10\text{ V}$	-	-	0.5	ns/V
		$V_{DD} = 15\text{ V}$	-	-	0.08	ns/V

## 10. Static characteristics

**Table 6. Static characteristics**

$V_{SS} = 0\text{ V}$ ;  $V_I = V_{SS}$  or  $V_{DD}$ ; unless otherwise specified.

Symbol	Parameter	Conditions	$V_{DD}$	$T_{amb} = -40\text{ °C}$		$T_{amb} = 25\text{ °C}$		$T_{amb} = 85\text{ °C}$		Unit
				Min	Max	Min	Max	Min	Max	
$V_{IH}$	HIGH-level input voltage	$ I_O  < 1\text{ }\mu\text{A}$	5 V	3.5	-	3.5	-	3.5	-	V
			10 V	7.0	-	7.0	-	7.0	-	V
			15 V	11.0	-	11.0	-	11.0	-	V
$V_{IL}$	LOW-level input voltage	$ I_O  < 1\text{ }\mu\text{A}$	5 V	-	1.5	-	1.5	-	1.5	V
			10 V	-	3.0	-	3.0	-	3.0	V
			15 V	-	4.0	-	4.0	-	4.0	V
$V_{OH}$	HIGH-level output voltage	$ I_O  < 1\text{ }\mu\text{A}$	5 V	4.95	-	4.95	-	4.95	-	V
			10 V	9.95	-	9.95	-	9.95	-	V
			15 V	14.95	-	14.95	-	14.95	-	V
$V_{OL}$	LOW-level output voltage	$ I_O  < 1\text{ }\mu\text{A}$	5 V	-	0.05	-	0.05	-	0.05	V
			10 V	-	0.05	-	0.05	-	0.05	V
			15 V	-	0.05	-	0.05	-	0.05	V
$I_{OH}$	HIGH-level output current	$V_O = 2.5\text{ V}$	5 V	-1.7	-	-1.4	-	-1.1	-	mA
		$V_O = 4.6\text{ V}$	5 V	-0.52	-	-0.44	-	-0.36	-	mA
		$V_O = 9.5\text{ V}$	10 V	-1.3	-	-1.1	-	-0.9	-	mA
		$V_O = 13.5\text{ V}$	15 V	-3.6	-	-3.0	-	-2.4	-	mA
$I_{OL}$	LOW-level output current	$V_O = 0.4\text{ V}$	5 V	0.52	-	0.44	-	0.36	-	mA
		$V_O = 0.5\text{ V}$	10 V	1.3	-	1.1	-	0.9	-	mA
		$V_O = 1.5\text{ V}$	15 V	3.6	-	3.0	-	2.4	-	mA
$I_I$	input leakage current		15 V	-	$\pm 0.3$	-	$\pm 0.3$	-	$\pm 1.0$	$\mu\text{A}$
$I_{DD}$	supply current	$I_O = 0\text{ A}$	5 V	-	20	-	20	-	150	$\mu\text{A}$
			10 V	-	40	-	40	-	300	$\mu\text{A}$
			15 V	-	80	-	80	-	600	$\mu\text{A}$
$C_I$	input capacitance		-	-	-	-	7.5	-	-	pF

## 11. Dynamic characteristics

**Table 7. Dynamic characteristics**

$V_{SS} = 0\text{ V}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ ; for test circuit see [Figure 8](#).

Symbol	Parameter	Conditions	$V_{DD}$	Extrapolation formula <sup>[1]</sup>	Min	Typ	Max	Unit	
$t_{PHL}$	HIGH to LOW propagation delay	CP to Q0; see <a href="#">Figure 7</a>	5 V	$78\text{ ns} + (0.55\text{ ns/pF}) C_L$	-	105	210	ns	
			10 V	$34\text{ ns} + (0.23\text{ ns/pF}) C_L$	-	45	90	ns	
			15 V	$22\text{ ns} + (0.16\text{ ns/pF}) C_L$	-	30	65	ns	
		Qn to Qn + 1	5 V	$53\text{ ns} + (0.55\text{ ns/pF}) C_L$	-	80	160	ns	
			10 V	$19\text{ ns} + (0.23\text{ ns/pF}) C_L$	-	30	60	ns	
			15 V	$12\text{ ns} + (0.16\text{ ns/pF}) C_L$	-	20	40	ns	
			MR to Qn; see <a href="#">Figure 7</a>	5 V	$153\text{ ns} + (0.55\text{ ns/pF}) C_L$	-	180	360	ns
				10 V	$79\text{ ns} + (0.23\text{ ns/pF}) C_L$	-	90	180	ns
				15 V	$62\text{ ns} + (0.16\text{ ns/pF}) C_L$	-	70	140	ns
$t_{PLH}$	LOW to HIGH propagation delay	CP to Q0; see <a href="#">Figure 7</a>	5 V	$78\text{ ns} + (0.55\text{ ns/pF}) C_L$	-	105	210	ns	
			10 V	$39\text{ ns} + (0.23\text{ ns/pF}) C_L$	-	50	95	ns	
			15 V	$27\text{ ns} + (0.16\text{ ns/pF}) C_L$	-	35	70	ns	
		Qn to Qn + 1	5 V	$43\text{ ns} + (0.55\text{ ns/pF}) C_L$	-	70	140	ns	
			10 V	$14\text{ ns} + (0.23\text{ ns/pF}) C_L$	-	25	50	ns	
			15 V	$12\text{ ns} + (0.16\text{ ns/pF}) C_L$	-	20	40	ns	
$t_t$	transition time	see <a href="#">Figure 7</a>	5 V	$10\text{ ns} + (1.00\text{ ns/pF}) C_L$	-	60	120	ns	
			10 V	$9\text{ ns} + (0.42\text{ ns/pF}) C_L$	-	30	60	ns	
			15 V	$6\text{ ns} + (0.28\text{ ns/pF}) C_L$	-	20	40	ns	
$t_W$	pulse width	CP = HIGH; minimum width; see <a href="#">Figure 7</a>	5 V		50	25	-	ns	
			10 V		25	15	-	ns	
			15 V		20	10	-	ns	
		MR = HIGH; minimum width; see <a href="#">Figure 7</a>	5 V		130	65	-	ns	
			10 V		95	50	-	ns	
			15 V		90	45	-	ns	
$t_{rec}$	recovery time	MR input; see <a href="#">Figure 7</a>	5 V		115	60	-	ns	
			10 V		65	35	-	ns	
			15 V		55	25	-	ns	
$f_{max}$	maximum frequency	see <a href="#">Figure 7</a>	5 V		5	10	-	MHz	
			10 V		13	25	-	MHz	
			15 V		18	35	-	MHz	

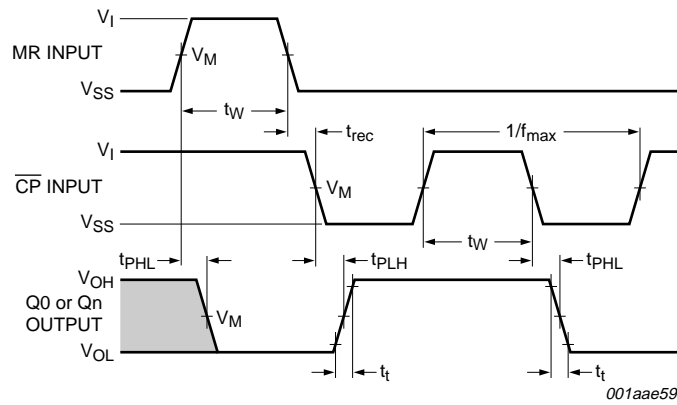
[1] The typical values of the propagation delay and transition times are calculated from the extrapolation formulas shown ( $C_L$  in pF).

**Table 8. Dynamic power dissipation  $P_D$**

$P_D$  can be calculated from the formulas shown.  $V_{SS} = 0\text{ V}$ ;  $t_r = t_f \leq 20\text{ ns}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ .

Symbol	Parameter	$V_{DD}$	Typical formula for $P_D$ ( $\mu\text{W}$ )	where:
$P_D$	dynamic power dissipation	5 V	$P_D = 600 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	$f_i$ = input frequency in MHz,
		10 V	$P_D = 2800 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	$f_o$ = output frequency in MHz,
		15 V	$P_D = 8200 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	$C_L$ = output load capacitance in pF, $V_{DD}$ = supply voltage in V, $\Sigma(C_L \times f_o)$ = sum of the outputs.

## 12. Waveforms

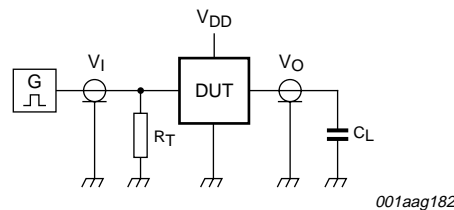


Measurement points are given in [Table 9](#).

**Fig 7. Propagation delays, minimum pulse widths, transition and recovery times and maximum clock frequency**

**Table 9. Measurement points**

Supply voltage	Input	Output
$V_{DD}$	$V_M$	$V_M$
5 V to 15 V	$0.5V_{DD}$	$0.5V_{DD}$



Test data is given in [Table 10](#).

Definitions for test circuit:

DUT = Device Under Test.

$C_L$  = load capacitance including jig and probe capacitance.

$R_T$  = termination resistance should be equal to the output impedance  $Z_o$  of the pulse generator.

**Fig 8. Test circuit**

Table 10. Test data

Supply voltage	Input		Load
$V_{DD}$	$V_I$	$t_r, t_f$	$C_L$
5 V to 15 V	$V_{SS}$ or $V_{DD}$	$\leq 20$ ns	50 pF



13. Package outline

DIP16: plastic dual in-line package; 16 leads (300 mil)

SOT38-4

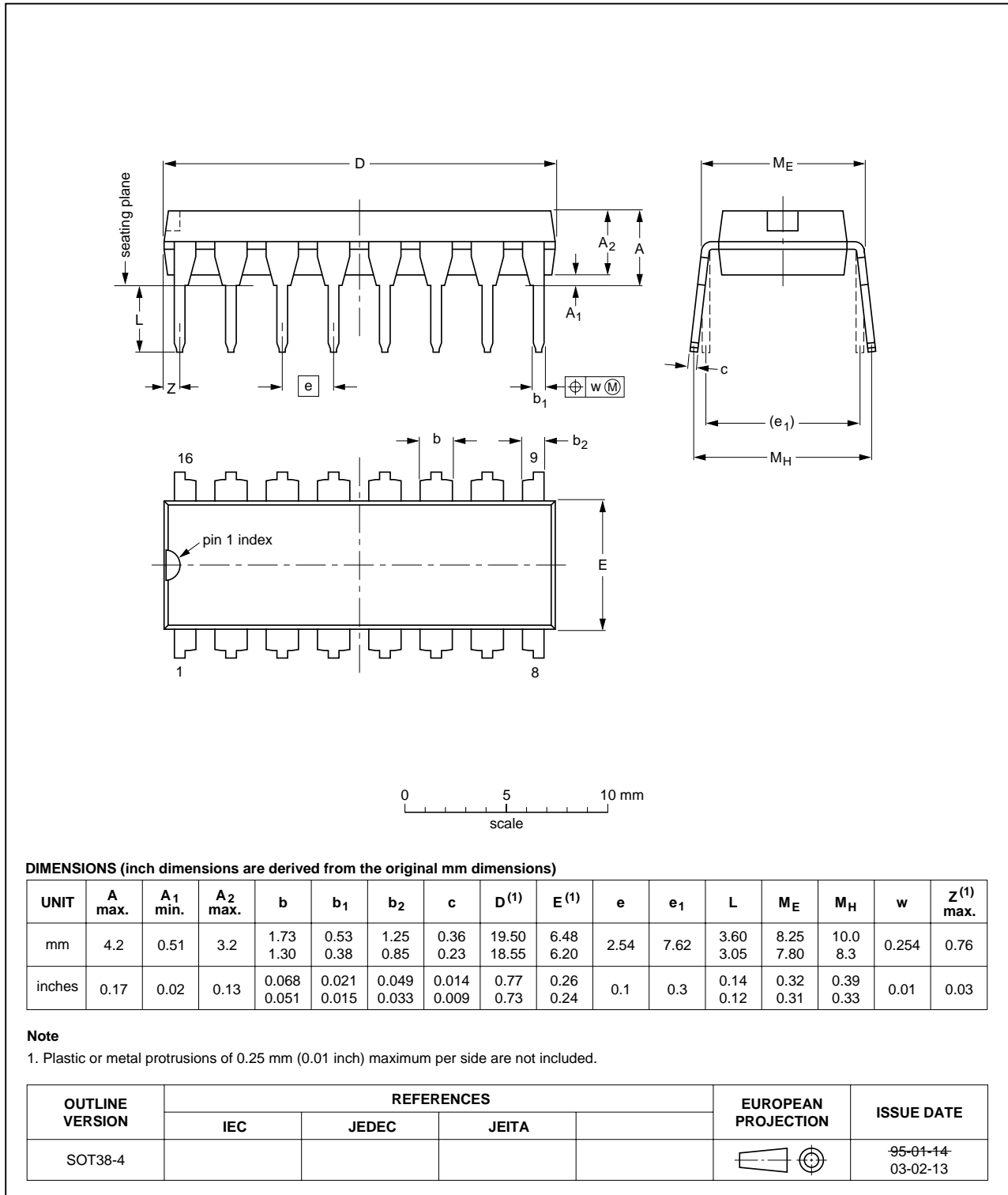


Fig 9. Package outline SOT38-4 (DIP16)

SO16: plastic small outline package; 16 leads; body width 3.9 mm

SOT109-1

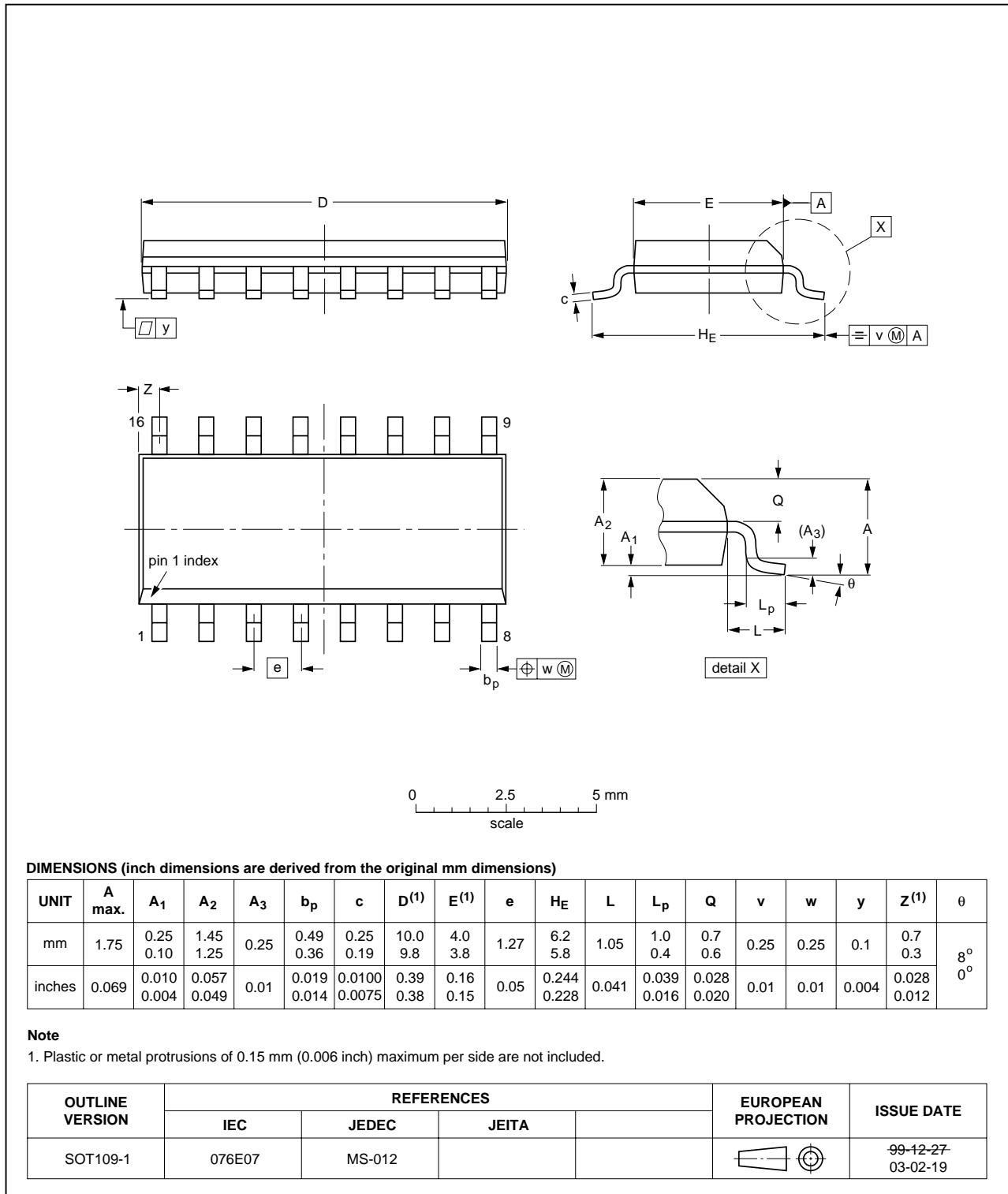


Fig 10. Package outline SOT109-1 (SO16)

## 14. Abbreviations

Table 11. Abbreviations

Acronym	Description
DUT	Device Under Test
ESD	ElectroStatic Discharge
HBM	Human Body Model
MM	Machine Model

## 15. Revision history

Table 12. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4020B_4	20081204	Product data sheet	-	HEF4020B_CNV_3
Modifications:	<ul style="list-style-type: none"> <li>The format of this data sheet has been redesigned to comply with the new identity guidelines of NXP Semiconductors.</li> <li>Legal texts have been adapted to the new company name where appropriate.</li> <li>Parallel output pins renamed Q0 to Q13 throughout.</li> <li>Temperature statement added to <a href="#">Section 1 “General description”</a>.</li> <li><a href="#">Section 2 “Features”</a> added.</li> <li><a href="#">Table 1 “Ordering information”</a> restructured.</li> <li>Package version SOT38-1 changed to SOT38-4 in <a href="#">Section 4</a>, and <a href="#">Figure 9</a>. Package SOT74 removed from <a href="#">Section 4</a>.</li> <li><a href="#">Figure 1 “Functional diagram”</a>, <a href="#">Figure 4 “Logic diagram”</a>, <a href="#">Figure 5 “Pin configuration”</a>, <a href="#">Figure 7 “Propagation delays, minimum pulse widths, transition and recovery times and maximum clock frequency”</a> and <a href="#">Figure 6 “Timing diagram”</a> changed for pin name changes.</li> <li><a href="#">Figure 2 “Logic symbol”</a> and <a href="#">Figure 3 “IEC Logic symbol”</a> added.</li> <li><a href="#">Table 2 “Pin description”</a> edited for pin name changes.</li> <li><a href="#">Section 7 “Functional description”</a> added.</li> <li><a href="#">Section 8 “Limiting values”</a> and <a href="#">Section 10 “Static characteristics”</a> added, taken from the HE4000B Family Specifications data sheet.</li> <li><math>t_{RMR}</math>, <math>t_{WCPH}</math> and <math>t_{WMRH}</math> changed to <math>t_{rec}</math> and <math>t_W</math> for <a href="#">Table 7 “Dynamic characteristics”</a> and <a href="#">Figure 7 “Propagation delays, minimum pulse widths, transition and recovery times and maximum clock frequency”</a>.</li> <li>50 % replaced by <math>V_M</math> for <a href="#">Figure 7 “Propagation delays, minimum pulse widths, transition and recovery times and maximum clock frequency”</a>.</li> <li><a href="#">Table 9 “Measurement points”</a>, <a href="#">Figure 8 “Test circuit”</a> and <a href="#">Table 10 “Test data”</a> added.</li> </ul>			
HEF4020B_CNV_3	19950101	Product specification	-	HEF4020B_CNV_2
HEF4020B_CNV_2	19950101	Product specification	-	-

## 16. Legal information

### 16.1 Data sheet status

Document status <sup>[1][2]</sup>	Product status <sup>[3]</sup>	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
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Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

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